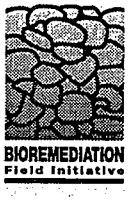
United States Environmental Protection Agency | Office of Research and Development Washington, DC 20460 | Office of Solid Waste and Emergency Response Washington, DC 20460

EPA/540/R-95/501 | September 1995

EPA

The Bioremediation in the Field Search System

Questionnaire



A cooperative effort of the U.S. EPA's Office of Research and Development, Office of Solid Waste and Emergency Response, and regional offices, and other federal agencies, state agencies, industry, and universities to expand the nation's field experience in bioremediation technologies for Superfund and other contaminated sites.

BIOREMEDIATION IN THE FIELD QUESTIONNAIRE

The purpose of this questionnaire is to collect information about sites where bioremediation is being considered or implemented, or has been completed. The following questions request information on the current status of your site. This information will be added to a data base of site information being developed by the U.S. Environmental Protection Agency (EPA) as a resource for EPA and other federal agencies, state project managers, consulting engineers, academia, and industry personnel considering the use of bioremediation. The data base currently contains information on 450 bioremediation sites—a number that is expected to increase markedly over the next few years.

Information in the data base is accessible through the Bioremediation in the Field Search System (BFSS), a software application available on EPA's Alternative Treatment Technology Clearinghouse (ATTIC) (703-908-2138), Cleanup Information (CLU-IN) (301-589-8366), and Office of Research and Development (ORD) (513-569-7610) electronic bulletin board systems. It also is available on diskette from EPA by calling 513-569-7562. BFSS will allow the user to search for information on specific types of sites, such as those treating a particular medium or contaminant or those using a particular treatment technology. A summary of information in the data base also appears in EPA's *Bioremediation in the Field* bulletin, a periodic update on field applications of bioremediation distributed to over 5,000 individuals.

The usefulness of both BFSS and the bulletin depends largely on the accuracy and completeness of responses to this questionnaire.

Please answer all questions that apply to your site. For questions that do not apply, answer "NA." For information that has not yet been established, please answer "NYE." If you have responded to previous questionnaires, some answers already are completed. Please verify that the answers are correct and current. If anything is inaccurate or has changed, please supply the correct information. Refer to the glossary of terms if necessary.

Site Report For:

_____

Please Return To:

BFEQ Support Personnel
Eastern Research Group, Inc. (ERG)
110 Hartwell Avenue
Lexington, MA 02173
U.S.A.

PART ONE: GENERAL SITE INFORMATION

Part one of this questionnaire (questions #1 through #11) requests general information about the site, including the name and location of the site; names, addresses, and phone numbers of site contacts; the regulatory authority or lead under which the site is being remediated; the predominant contaminant at the site; and a brief site description.

*** PLEASE NOTE ***

If you have filled out a previous questionnaire, please check to make sure that all printed responses are correct, current, and complete. If the site has **never used or tested** bioremediation and is no longer considering bioremediation, you do not need to fill out the rest of this questionnaire. In either case, we need this information to update our site data base and bulletin, so please check the appropriate box below and send the questionnaire back to us by the date indicated on the front page of the questionnaire.

❑ All printed responses are correct, current, and complete.

❑ This site has never used or tested bioremediation and is no longer considering bioremediation.

If the site has tested bioremediation at laboratory or pilot scale, please complete the questionnaire, even if the tests were unsuccessful and full-scale bioremediation is not being considered.

PART ONE: GENERAL SITE INFORMATION

Site Identification

1. Site Name: _____
2. City: _____
   State (Province), Zip (Mail Code) _____
3. Country: _____
4. EPA Region (if U.S. site): _____

Site Contact(s)

5. **Information Supplied by:**

Name: _____
Address: _____
_____
_____
_____
_____
Phone: _____
Fax: _____
E-Mail: _____

Affiliation:
- ❑ Federal (or National) Organization
- ❑ State (or Provincial) Organization
- ❑ Municipal (or Local) Organization
- ❑ Industry
- ❑ Contractor/Engineering Firm
- ❑ Technology Vendor
- ❑ Other (specify): _____

(Providing the e-mail address will allow us to send you future questionnaires via the Internet. If you do not have this capability or prefer not to exercise it, you do not need to fill in this piece of information.)

6. **Additional Government Agency Contact:**

Name: _____
Address: _____
_____
_____
_____
_____
Phone: _____
Fax: _____
E-Mail: _____

Affiliation:
- ❑ Federal (or National) Organization
- ❑ State (or Provincial) Organization
- ❑ Municipal (or Local) Organization
- ❑ Other (specify): _____

7. **Additional Private Sector Contact:**

Name: _____
Address: _____
_____
_____
_____
_____
Phone: _____
Fax: _____
E-Mail: _____

Affiliation:
- ❑ Industry
- ❑ Contractor/Engineering Firm
- ❑ Technology Vendor
- ❑ Other (specify): _____

PART ONE: GENERAL SITE INFORMATION

8. Site Lead

[In most cases, check only one box. If there is more than one lead, please explain under comments below how the authority is divided, e.g., ground-water contamination is under RCRA jurisdiction; soil contamination is under UST jurisdiction.]

United States Sites:

- ❑ CERCLA Fund Lead: Covers Federal Lead.
- ❑ CERCLA Enforcement Lead: Covers PRP Lead, Enforcement Lead for RA, Federal Facility Enforcement Lead.
- ❑ CERCLA State Lead: Covers State Lead Enforcement, State/Federal Lead.
- ❑ Federal Facility: Covers DIRP, DOE, other federal agency facilities conducting remedial activities.
- ❑ RCRA Lead (Federal): Federal RCRA enforcement.
- ❑ RCRA Lead (State): State authority for RCRA enforcement
- ❑ UST Lead.
- ❑ TSCA Lead (Federal): Depends on whether the state is authorized for enforcement.
- ❑ TSCA Lead (State): See TSCA Lead (Federal).
- ❑ Other (please specify) _____

International Sites:

- ❑ Government Lead (please specify) _____
- ❑ Private Sector Lead (please specify) _____

Comments:

PART ONE: GENERAL SITE INFORMATION

Site Characterization/Description

9. How would you characterize the contamination ***being bioremediated or considered for bioremediation*** at this site? Check all that apply.

- ❑ Wood Preserving
- ❑ Petroleum
- ❑ Pesticide/Herbicide
- ❑ Solvent
- ❑ Other (please specify) _____

(Please categorize the contamination using one of the named categories, whenever possible, rather than listing an individual contaminant(s). The purpose of the question is to allow a broad characterization of the site. You will have an opportunity to list *all* individual contaminants to be treated in a later question.)

10. Please provide a short description of the facility or contaminated site (e.g., inactive wood preserving site, leaking underground storage tank, RCRA land treatment facility to treat oil refinery sludges):

(If your site has a number of separate areas being treated or considered for treatment using the same or different bioremediation processes, please list and describe the separate subsites here.)

Other Sites

11. If you are aware of other bioremediation sites not already in BFSS or listed in the "Field Applications of Bioremediation" table in the *Bioremediation in the Field* bulletin, please specify the site(s) below.

Site Name:	_____	Site Name:	_____
City/State:	_____	City/State:	_____
Contact:	_____	Contact:	_____
Phone:	_____	Phone:	_____

PART TWO: BIOTREATMENT PROCESS INFORMATION

Part two of this questionnaire (questions #12 through #31) requests information about a specific biotreatment process being considered or implemented at the site, including the type of technology being used; the laboratory-, pilot-, or full-scale status of the technology; the media and contaminants being treated; the target cleanup levels; and the performance of the technology. If a biotreatment process is being tested at laboratory or pilot scale, your answers to part two of the questionnaire should apply to the current scale of the technology, not to anticipated full-scale activities.

Note that some questions are only applicable under certain circumstances. For example, question #31 is appropriate for cost information for full-scale biotreatment processes only. Please read carefully to avoid questions that do not apply to a particular biotreatment process.

***** PLEASE NOTE *****

If more than one biotreatment process is being considered or implemented at this site, or if the same process is being used to treat separate areas of contamination, please photocopy and complete part two of the questionnaire ***for each process or separate contaminated area***.

Please enter the number of separate biotreatment processes at your site: ___

PART TWO: BIOTREATMENT PROCESS _ OF _

Treatment Technology

12. Please identify one biotreatment process being considered or implemented at this site.

(In most cases, check only one technology. Checking more than one technology implies that the two or more technologies are being used together in a *single process treatment train.* If this is the case, please explain in question #19 how these technologies are used in conjunction with one another.)

Ex Situ Processes

Treatments Involving a Reactor

- ❑ Activated Sludge Reactor
- ❑ Extended Aeration Reactor
- ❑ Contact Stabilization Reactor
- ❑ Attached Growth
  - ❑ Fixed Film Reactor
  - ❑ Fluidized Bed Reactor
- ❑ Sequencing Batch Reactor
- ❑ Slurry Reactor
- ❑ Other (please specify) _____

Treatments Not Involving a Reactor

- ❑ Aerated Lagoon
  Solid Phase
  - ❑ Prepared Bed (Land Treatment)
  - ❑ Pile Treatment
- ❑ Other (please specify) _____

In Situ Processes

- ❑ Natural Attenuation (Intrinsic Bioremediation)
- ❑ Air Sparging (Biosparging)
- ❑ Bioventing
- ❑ Confined Treatment Facility for Sediments
- ❑ In Situ Ground Water Bioremediation
- ❑ In Situ Sediment Bioremediation
- ❑ In Situ Soil Bioremediation
- ❑ Other (please specify) _____

13. If the technology is in situ, what amendments are used?

- ❑ Hydrogen Peroxide
- ❑ Oxygen
- ❑ Nutrients (please specify) _____
- ❑ Other (please specify) _____

PART TWO: BIOTREATMENT PROCESS _ OF _

14. If the technology involves a reactor, does the reactor treat the material as a solid, liquid, or gas?

- ❑ Solid
- ❑ Liquid
- ❑ Gas

15. If the technology involves a reactor, how would you describe the reactor flow?

- ❑ Batch
- ❑ Plug
- ❑ Completely Mixed

16. What are the growth conditions for the microorganisms?

- ❑ Aerobic
- ❑ Anaerobic

17. What is the source of the microorganisms?

(Check exogenous only if the organisms are actually brought in from another site, cultured in the lab, or engineered. If organisms are merely moved for application from one part of the site to another or from a contaminated area to a reactor or other treatment unit on site, then the source is still considered *indigenous*.)

- ❑ Indigenous
- ❑ Exogenous

  Specify type(s) of exogenous organism: _____

PART TWO: BIOTREATMENT PROCESS _ OF _

18. Please check any nonbiological technologies that are being tested or implemented at the site in conjunction with this technology.

- ❑ Chemical Extraction
- ❑ Chemical Treatment
- ❑ In Situ Soil Flushing
- ❑ In Situ Vitrification
- ❑ Soil Washing
- ❑ Vacuum Extraction
- ❑ Thermal Desorption
- ❑ Other (please specify) _____

_____

19. Please describe the treatment process in more detail.

(If the bioremediation process is used in conjunction with a nonbiological technology, or two distinct bioremediation technologies are being used sequentially in the same treatment train, explain how the technologies are being used together in a single process.)

20. Is migration of contaminants an issue with the use of this technology at this site? If so, what containment or confinement technology is being used?

PART TWO: BIOTREATMENT PROCESS _ OF _

Contaminated Media

21. Please identify the contaminated medium or media ***being treated or considered for treatment by this biological technology.***

- ❑ Air
- ❑ Sediments
- ❑ Sludge
- ❑ Soil (please indicate zone below)
  - ❑ Vadose Zone
  - ❑ Saturated Zone
- ❑ Water (please indicate type below)
  - ❑ Ground Water
  - ❑ Surface Water

22a. What texture classification system are you using for *soil*?

- ❑ United States Department of Agriculture (USDA)
- ❑ ASTM/Unified Soil Classification System (USCS)
- ❑ Canada Soil Survey Committee (CSSC)
- ❑ International Soil Science Society (ISSS)
- ❑ British Standards Institution (BSI)
- ❑ Other (please specify) _____

(Please fill in the information for the corresponding texture classification system only.)

USDA Texture Class

- ❑ Sand
- ❑ Loamy Sand
- ❑ Sandy Loam
- ❑ Loam
- ❑ Silt
- ❑ Silt Loam
- ❑ Clay Loam
- ❑ Silty Clay Loam
- ❑ Sandy Clay
- ❑ Silty Clay
- ❑ Clay

Typical Particle Size Distribution

_____ % Clay (<0.002 mm)
_____ % Sand (0.05 to 2.0 mm)
_____ % Silt (0.002 to 0.05 mm)
_____ % Coarse Fragments (>2.0 mm)

ASTM/USCS Texture Class

- ❑ CH
- ❑ CL
- ❑ MH
- ❑ ML
- ❑ SC
- ❑ SM
- ❑ SP
- ❑ SW
- ❑ GC
- ❑ GM
- ❑ GP
- ❑ GW

CSSC Typical Particle Size Distribution

_____ % Clay (<0.002 mm)
_____ % Sand (0.05 to 2.0 mm)
_____ % Silt (0.002 to 0.05 mm)
_____ % Coarse Fragments (>2.0 mm)

ISSS Typical Particle Size Distribution

_____ % Clay (<0.002 mm)
_____ % Sand (0.02 to 2.0 mm)
_____ % Silt (0.002 to 0.02 mm)
_____ % Coarse Fragments (>2.0 mm)

BSI Typical Particle Size Distribution

_____ % Clay (<0.002 mm)
_____ % Sand (0.06 to 2.0 mm)
_____ % Silt (0.002 to 0.06 mm)
_____ % Coarse Fragments (>2.0 mm)

Other Typical Particle Size Distribution

_____ % Clay (<___ mm)
_____ % Sand (__ to __ mm)
_____ % Silt (__ to __ mm)
_____ % Coarse Fragments (>___ mm)

PART TWO: BIOTREATMENT PROCESS _ OF _

22b. What texture classification system are you using for *sediments*?

- ❑ United States Department of Agriculture (USDA)
- ❑ ASTM/Unified Soil Classification System (USCS)
- ❑ Canada Soil Survey Committee (CSSC)
- ❑ International Soil Science Society (ISSS)
- ❑ British Standards Institution (BSI)
- ❑ Other (please specify) _____

(Please fill in the information for the corresponding texture classification system only.)

USDA Texture Class

❑ Sand	❑ Loam	❑ Clay Loam	❑ Silty Clay
❑ Loamy Sand	❑ Silt	❑ Silty Clay Loam	❑ Clay
❑ Sandy Loam	❑ Silt Loam	❑ Sandy Clay	

Typical Particle Size Distribution

_____ % Clay (<0.002 mm) _____ % Sand (0.05 to 2.0 mm)

_____ % Silt (0.002 to 0.05 mm) _____ % Coarse Fragments (>2.0 mm)

ASTM/USCS Texture Class

❑ CH	❑ CL	❑ MH	❑ ML	❑ SC	❑ SM
❑ SP	❑ SW	❑ GC	❑ GM	❑ GP	❑ GW

CSSC Typical Particle Size Distribution

_____ % Clay (<0.002 mm) _____ % Sand (0.05 to 2.0 mm)

_____ % Silt (0.002 to 0.05 mm) _____ % Coarse Fragments (>2.0 mm)

ISSS Typical Particle Size Distribution

_____ % Clay (<0.002 mm) _____ % Sand (0.02 to 2.0 mm)

_____ % Silt (0.002 to 0.02 mm) _____ % Coarse Fragments (>2.0 mm)

BSI Typical Particle Size Distribution

_____ % Clay (<0.002 mm) _____ % Sand (0.06 to 2.0 mm)

_____ % Silt (0.002 to 0.06 mm) _____ % Coarse Fragments (>2.0 mm)

Other Typical Particle Size Distribution

_____ % Clay (<___ mm) _____ % Sand (__ to __ mm)

_____ % Silt (__ to __ mm) _____ % Coarse Fragments (>___ mm)

PART TWO: BIOTREATMENT PROCESS _ OF _

23. Please indicate the volume of contaminated media ***being treated or considered for treatment by this technology***, the total volume of these contaminated media at the site, and the percent of the total being treated or considered for treatment with this process. (The first row has been completed as an example.)

Medium	Volume Under Bioremediation	Total Volume at Site	Percent of Total Volume at Site
Example: Soil (vadose)	2,000 cubic yards	10,000 cubic yards	20%

PART TWO: BIOTREATMENT PROCESS _ OF _

Contaminants and Cleanup Level Data

24. For each medium, please specify the contaminants ***being treated or considered for treatment by this biotreatment process*** and fill in any available information pertaining to original contaminant concentrations, cleanup levels, and technology performance. Do ***not*** fill in information on contaminants not undergoing bioremediation (see question #25). If you need more space, please photocopy the table. (One row has been completed as an example.)

The data included in this table for rate of reaction, lowest concentration achieved, and time to achieve cleanup level should be based on whatever scale of testing or remediation you are currently undergoing, e.g., if you are doing pilot-scale testing, these data should reflect pilot-scale results.)

Medium (Please select from list in question #21)	Contaminant	Maximum Original Concentration	Target or Required Cleanup Level	Basis for Cleanup Level	Rate of Reaction	Lowest Concentration Achieved	Time to Achieve Cleanup Level
Example: soil (vadose)	carcinogenic PAHs	1,500 mg/kg	160 mg/kg	Risk-based	2 mg/kg/day	100 mg/kg	2 years

25a. What other contaminants are present that will not undergo bioremediation?

b. Does the presence of the other contaminants affect the performance of the biological technology at the site? If so, how?

PART TWO: BIOTREATMENT PROCESS _ OF _

Status

26. Are LABORATORY-SCALE treatability or feasibility studies of this biotreatment process *being considered, being conducted,* or *completed* on material from the site?

- ☐ Yes, being considered.
- ☐ Yes, being conducted.
- ☐ Yes, completed.
- ☐ No.

If so, provide the expected or actual dates for start and completion of laboratory-scale activity:

Start: _____ Completion: _____

27. Are PILOT-SCALE treatability or feasibility studies of this biotreatment process *being considered, being conducted,* or *completed* at the site?

- ☐ Yes, being considered.
- ☐ Yes, being conducted.
- ☐ Yes, completed.
- ☐ No.

If so, provide the expected or actual dates for start and completion of pilot-scale activity:

Start: _____ Completion: _____

28. Is FULL-SCALE remediation using this biotreatment process *being considered, being conducted,* or *completed* at the site?

- ☐ Yes, being considered.
- ☐ Yes, being conducted.
- ☐ Yes, completed.
- ☐ No. (Please elaborate in question #30.)

If so, please check the current stage of full-scale remediation and provide the expected or actual date for the ***start*** of each stage:

- ☐ Predesign _____
- ☐ Design _____
- ☐ Installation _____
- ☐ Operational _____
- ☐ Completed _____

29. Please identify any problems or obstacles associated with bioremediation or other significant information on the status of bioremediation. (These might include technical, cost-related, or regulatory obstacles.)

30. If full-scale bioremediation has not been considered or is no longer being considered at this site, please explain why.

PART TWO: BIOTREATMENT PROCESS _ OF _

Costs

31. Please indicate the capital costs (startup and construction) and operation and maintenance (O&M) costs *associated with the FULL-SCALE application of this technology*. If separate figures for capital and O&M costs are not available, enter the total incurred and expected costs. If this biotreatment process is currently operating at laboratory or pilot scale, you do not need to fill in this information.

Costs	Per Year	Incurred	Total Expected
Capital	NA		
O&M			
Total			

Please indicate the monetary units used: _____

GLOSSARY OF BIOREMEDIATION TERMS

Site Lead	Agency or program having jurisdiction over site cleanup.
Ex Situ Treatment Processes	
Treatments Involving a Reactor	
Ex Situ Process	Process that involves the removal of the contaminated medium or media from its original location to another area for treatment. Processes that involve removal of the contaminated material, mixing, and then replacement at the original site are also considered ex situ.
Reactor	A contained vessel in which biological treatment takes place.
Activated Sludge Reactor	Technology in which biomass is suspended in liquid, captured in the clarifier, and recycled to the reactor; the contact time between the waste and the biomass is controlled by wasting excess biomass.
Extended Aeration Reactor	Technology in which biomass is suspended in liquid, captured in the clarifier, and recycled to the reactor; a long contact time is created by enlarging the aeration basin.
Contact Stabilization Reactor	Technology in which waste contacts the biomass suspended in liquid in the first aeration tank and contaminants are adsorbed to the clarified biomass; then they are digested in the second aeration tank.
Fixed Film Reactor	Technology in which biomass is retained in the system by using static support media (e.g., a trickling filter).
Fluidized Bed Reactor	Technology in which bacteria are attached to a support medium, which is fluidized in the reactor.
Sequencing Batch Reactor	A self-contained treatment system that incorporates equalization, aeration, and clarification using a draw and fill approach on wastewater sludges.
Slurry Reactor	Technology in which contaminants are treated in a soil slurry (a thin mixture of soil and water), with nutrients and oxygen added as needed; water and soil must be separated after treatment, but clean soil is left on site.
Treatments Not Involving a Reactor	
Aerated Lagoon	Treatment in which soil, sludge, or sediment is mixed with water to form a slurry. The slurry is placed in a lagoon and mechanically agitated so that the biomass is kept suspended in liquid with aeration. Nutrient, oxygen, pH, and temperature conditions are controlled. After the process is completed, the slurry is dewatered and the treated material is disposed of.
Prepared Bed	Process in which waste is applied onto or incorporated into the soil surface in a facility or lined treatment bed. Contaminants are treated by microorganisms typically indigenous to the existing soil matrix; nutrients, moisture, and oxygen can be added to optimize growth conditions. If the waste remains at the facility after closure, the land treatment facility becomes a disposal facility.
Pile Treatment	Process in which a noncontainerized accumulation of solid, nonflowing waste is treated or stored under controlled nutrient, oxygen, pH, and temperature conditions.

In Situ Treatment Processes	
In Situ Process	Process that leaves contaminated medium or media in place for treatment.
Natural Attenuation (Intrinsic Bioremediation)	Natural attenuation is the biodegradation, dispersion, dilution, sorption, volatilization, and/or chemical and biochemical stabilization of contaminants to effectively reduce contaminant toxicity, mobility, or volume to levels that are protective of human health and the ecosystem.
Air Sparging (Biosparging)	Air is injected below the water table, creating bubbles in contaminated ground water. The air bubbles contact dissolved and adsorbed contaminants in the aquifer, increasing oxygen concentrations and stimulating indigenous microbial activity. Sparging also causes contaminants to volatilize and be transported to the vadose zone, where they can be treated by another technology, such as bioventing or soil vapor extraction.
Bioventing	Injection or extraction wells are used to induce a dynamic flow of air through contaminated soil above the water table. Air flow rates are adjusted to increase soil oxygen concentrations and stimulate indigenous microbial activity without releasing volatile emissions. In some bioventing systems, a nutrient solution is injected with the air or percolated through the soil.
Confined Treatment Facility for Sediments	Caissons are constructed to contain the sediments in the environment in which they are found. Stirring mechanisms then can be used to agitate the contaminated material, and incorporate microorganisms, nutrients, and electron acceptors.
In Situ Ground Water Treatment	Injection wells can be used to circulate nutrients and electron acceptors through contaminated aquifers. In most systems, ground water is pumped through a recovery well down gradient of the contaminated area, treated to some extent, then reinjected up gradient of the contaminated area with additives that enhance biodegradation. The effectiveness of in situ ground water bioremediation depends on maintaining contact between contaminants and injected amendments.
In Situ Sediment Treatment	Biodegradable contaminants are treated by microorganisms within the environment in which they are found. This process usually is anaerobic and involves the delivery of electron acceptors and other appropriate amendments to the contaminated sediments.
In Situ Soil Treatment (Land Treatment)	Biodegradable contaminants are treated by microorganisms within the environment in which they are found. This process usually is aerobic and involves injection of oxygen, other electron acceptors, and other appropriate amendments to the contaminated soil. Permeable soils with high moisture content are most appropriate for in situ treatment.
Amendment	Chemical additions such as electron acceptors or nutrients to enhance bioprocesses.
Media	
Sediments	Sediments refer to aquifer materials including gravelly sand, clayey sand, and sandy clay originating from sedimentary rock. Sediments also are accumulations of such materials as sand and volcanic ash from the atmosphere; of stream gravel, sand, and mud on the lands; and of gravels, sand, clay, and organic remains on the sea floor.
Soil	Soil is the loose surface material of the earth in which plants grow.

Media (continued)	
Vadose Zone	The vadose zone is the region extending from the ground surface of the earth to the upper surface of the principal water-bearing formation.
Saturated Zone	The saturated zone extends from the upper surface of saturation down to underlying impermeable rock. Generally, the water table forms the upper surface of the zone of saturation. This is defined as the surface of atmospheric pressure and appears as the level at which water stands in a well penetrating the aquifer.
Ground Water	Groundwater is water occurring in the zone of saturation.
Microorganism Growth Conditions	
Aerobic	In the presence of oxygen. Aerobic metabolism involves energy-yielding oxidation reactions in which hydrogen is transferred to oxidized pyridine nucleotides (NAD and NADP).
Anaerobic	In the absence of oxygen. Anaerobic metabolism involves energy-yielding reactions in which the final electron acceptor is a compound other than molecular oxygen, such as sulfate or nitrate.
Microorganism Source	
Indigenous	Occurring naturally at a site. Organisms that are moved from one location at the site to another (e.g. to a reactor) to facilitate treatment of the original contaminated medium are still considered indigenous.
Exogenous	Not native to a site. These include organisms that are brought in from another site, cultured in a lab, or engineered.
Contaminants and Cleanup Level Data	
Maximum Original Concentration	Maximum level of contamination detected prior to start of bioremediation.
Basis for Cleanup Level	Regulatory or other standard that establishes cleanup levels.
Rate of Reaction	Reduction of contaminant concentration per unit time (mg/L/day).
Lowest Concentration Achieved	Lowest contaminant concentration at current scale of remediation, or final concentration if full-scale bioremediation has been completed.
Time to Achieve Cleanup Level	Time required to achieve cleanup goals for the entire contaminated area being treated or tested.
Treatment Status	
Laboratory Scale	Undertaken in the laboratory under controlled conditions.
Treatability or Feasibility Studies	Studies to test the effectiveness of specific techniques for remediating specific media and contaminants. These studies also identify existing site problems and examine potential remedial alternatives, considering technical, regulatory, environmental, public health, and cost issues.
Pilot Scale	Performed on test plots and control plots under field conditions. If a contaminated area is small enough, pilot-scale treatment may be able to achieve cleanup level goals.
Full-Scale Remediation	Remediation employing a specific technology or technologies to clean up contaminants over an entire site or contaminated area. Full-scale remediation often is preceded by treatability or feasibility studies.